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rings. Of these the light takes advantage for producing a symmetrical effect, just as in the formation of the rainbow it selects those individual drops of moisture which serve its purpose, while the remainder of the drops are inoperative. A piece of very delicately ground glass accomplishes the same result. In the atmosphere, the place of the lycopodium powder is filled by the particles of moisture existing in the vesicular state; and the smaller these particles the larger will be the diameters of the coronæ which they produce. In this way these particles are proved to vary between the .001 and the .002 of one inch in diameter.*

Coronæ indicate the presence of the *cumulus* cloud; but halos imply the *cirrus* cloud, floating at great heights, and within the region of perpetual congelation. For halos are seen even in the summer and in the tropics. By revealing the incipient gathering of the cirrus cloud, they may foretell the approach of a storm.

Six hundred and twenty-first Meeting.

May 24, 1870. — ANNUAL MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary communicated letters relative to exchanges, and read a report from the Council proposing nominations for Foreign Honorary and Associate Membership.

The Treasurer presented his report for the past year, and read a synopsis of it. The report was received, to be entered on the records.

Professor Lovering reported from the Committee of Publication its expenditures for the past two years. The report was accepted.

Professor F. H. Storer reported for the Committee on the Library on the condition of the Library.

Professor Winlock reported, from the Rumford Committee, the completion of Vol. I. of Count Rumford's works, and recommendations of this committee for appropriations from the Rumford Fund. This report was accepted, and in accordance with its recommendations the following votes were passed: —

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* Kaemtz's Complete Course of Meteorology, p. 111.

Voted, That fifteen hundred dollars be appropriated from the Rumford Fund to continue the publication of Count Rumford's works.

Voted, That five hundred dollars in gold be appropriated from the Rumford Fund to be expended by Dr. B. A. Gould in the purchase of photometric and spectroscopic apparatus for an observatory at Cordova in the Argentine Republic.

The Recording Secretary returned the papers of Mr. W. B. Burden, for the Committee to which they were referred, with the recommendation that they be referred to the astronomical section of the Academy.

It was voted to adjourn this meeting, at its close, to the second Tuesday in June.

The following gentlemen were elected members of the Academy: —

Charles C. Perkins, of Boston, to be a Resident Fellow in Class III., Section 4.

Nathaniel Holmes, of Cambridge, to be a Resident Fellow in Class III., Section 1.

Raphael Pumpelly, of Cambridge, to be a Resident Fellow in Class II., Section 1.

George Derby, of Boston, to be a Resident Fellow in Class II., Section 3.

Simon Newcomb, of Washington, to be an Associate Fellow in Class I., Section 1.

Truman H. Safford, of Chicago, to be an Associate Fellow in Class I., Section 1.

Henry J. Clark, of Lexington, Ky., to be an Associate Fellow in Class II., Section 3.

Alexander Braun, of Berlin, to be a Foreign Honorary Member in Class II., Section 2, in the place of the late Von Martius.

Charles Merivale, of Oxford, to be a Foreign Honorary Member in Class III., Section 3, in the place of the late Dean Milman.

The annual election resulted in the choice of the following officers for the ensuing year: —

Asa Gray, *President.*
George T. Bigelow, *Vice-President.*
Joseph Lovering, *Corresponding Secretary.*
Edward C. Pickering, *Recording Secretary.*
Charles J. Sprague, *Treasurer.*
Frank H. Storer, *Librarian.*

Council.

Thomas Hill,
Josiah P. Cooke, of Class I.
John B. Henck,
Louis Agassiz,
Jeffries Wyman, of Class II.
Charles Pickering,
Robert C. Winthrop,
George E. Ellis, of Class III.
Andrew P. Peabody,

Rumford Committee.

James B. Francis,
Morrill Wyman,
Edward C. Pickering,
Joseph Winlock,
Wolcott Gibbs,
Josiah P. Cooke,
Frank H. Storer.

Committee of Finance.

Asa Gray,
Charles J. Sprague, *ex officio*, by statute.
Thomas T. Bouvé, by election.

The other Standing Committees were appointed, on the nomination of the President, as follows: —

Committee of Publication.

Joseph Lovering,
Jeffries Wyman,
Francis J. Child.

Committee on the Library.

Francis Parkman, Charles Pickering,
John Bacon.

Committee to audit the Treasurer's Accounts.

Charles E. Ware, Theodore Lyman.

Professor Joseph Winlock exhibited a photograph of the sun taken with a lens of forty feet focus, and four inches aperture. As it is difficult to place a tube of this length in an inclined position, it is laid horizontally, and an image of the sun is reflected into it by a plane mirror of unsilvered glass. When this mirror was blackened on one side, it became heated to such an extent as to shorten the focus of the lens nearly three feet. The image obtained is about four inches in diameter, and is free from the distortion produced by an eye-piece. The exposure is instantaneous, and is effected by passing a diaphragm with a slit in it between the lens and mirror. A better effect is thus obtained than by the usual method of placing it near the plate-holder. The lens, which was made by Messrs. Clark and Sons, is not achromatic, as its slight curvature rendered this unnecessary. It was corrected for spherical aberration by means of an artificial star, produced by a soda flame, and a collimator, of an aperture somewhat greater than that of the lens.

The Corresponding Secretary presented the following annual report of the Council: —

Since the last report of the Council, the following gentlemen have been elected members of the Academy: —

William T. Brigham, of Boston, to be a Resident Fellow in Class II., Section 1.

Algernon Coolidge, of Boston, to be a Resident Fellow in Class II., Section 1.

Alfred P. Rockwell, of Boston, to be a Resident Fellow in Class I., Section 4.

Alpheus Hyatt, of Salem, to be a Resident Fellow in Class II., Section 3.

Edward S. Morse, of Salem, to be a Resident Fellow in Class II., Section 3.

Thomas W. Parsons, of Boston, to be a Resident Fellow in Class III., Section 4.

James M. Barnard, of Boston, to be a Resident Fellow in Class II., Section 3.

Henry L. Whiting, of Boston, to be a Resident Fellow in Class I., Section 2.

Nathaniel S. Shaler, of Cambridge, to be a Resident Fellow in Class II., Section 1.

During the same period, the Academy has lost five members by death, viz.: —

Two Resident Fellows, one Associate Fellow, and two Foreign Honorary Members.

THOMAS SHERWIN was born in Westmoreland, New Hampshire, March 26, 1799. His parents in a few years removed to New Ipswich in the same State, and soon afterwards to the adjoining town of Temple. At the age of eight, soon after the death of his mother, Thomas went to live with a relative, Dr. Crombie, of Temple, and remained with him six years. In 1813 he spent a short time in Ipswich Academy; but his father having met with misfortunes, he was compelled to leave school, and, in September of the same year, he was apprenticed at Groton, Massachusetts, to learn the trade of a clothier, — a trade which at that time appears to have consisted mainly in taking cloth as it came from the domestic looms, and fulling, dyeing, and dressing it for the market. Here he remained eight years, working diligently at his trade, and winning the esteem and confidence of his employers. He was able to attend the district school two months in the year; but his natural love of learning often led him to devote one or two hours to study after working at the mill until ten o'clock at night.

His desire to obtain a college education had now become so strong that he left his trade, and, after teaching a district school in Harvard for a short time, began his preparation for college at the academy in Groton in April, 1820. He completed it at the New Ipswich Academy, and entered Harvard College in 1821. Here, notwithstanding his imperfect preparation, he soon placed himself among the foremost scholars, particularly in mathematics, and graduated with honor in

1825. For a year he had charge of the academy at Lexington, and was then appointed tutor in mathematics in the College. In 1827 he commenced civil engineering with Loammi Baldwin, and, in the same year, under James Hayward, was employed on the preliminary survey of the Boston and Providence Railroad. Relinquishing this business on account of a severe illness, he in 1828 opened a private school for boys, in Boston, and the next year was elected sub-master of the English High School. In 1837 he was elected master of the school, and continued to hold the position to the time of his death.

As master of the English High School, Mr. Sherwin gained his highest distinction. The best work of his life was here. He inspired his pupils with his own love of thoroughness, and taught them, not more by precept than by example, to think for themselves, and to aim at a noble manhood. Under his charge the school ranked among the best in the country. Indeed, Mr. Fraser, in his report to the British Parliament on the schools of this country, says: "The English High School struck me as the model school of the United States."

In all educational matters Mr. Sherwin took an active interest. He aided in the establishment of the American Institute of Instruction and of the Massachusetts State Teachers' Association, and became President of each of these bodies. He was also one of the founders of the Massachusetts Teacher, and for several years had charge of its mathematical department. He shared in the organization of the Massachusetts Institute of Technology, and, as a member of its government, was one of its most active and earnest promoters.

Mr. Sherwin wrote various addresses and lectures on educational subjects, and contributed several papers to the Mathematical Monthly. In connection with Mr. S. P. Miles, he published a collection of Mathematical Tables. He was the author, also, of two works on Algebra, — an "Elementary Treatise on Algebra," and a "Common School Algebra," — both of which have long held a high place in our schools.

Mr. Sherwin was elected a Fellow of this Academy in 1836. In 1868 he was elected a member of the New England Historic-Genealogical Society.

Mr. Sherwin died, very suddenly, July 23, 1869. On that day, not feeling quite well, he consulted a physician, walked home in a cheerful mood, and, after some conversation with his family and a walk in his garden, went to his room, took a book, and in a moment departed. In all the relations of life Mr. Sherwin sustained a high reputation. In boyhood diligent and faithful, in youth persevering in his efforts to secure a liberal education, as a teacher attaining rare success by conscientious devotion to the best interests of his pupils, patriotic when his country was in danger, zealous in promoting the cause of sound education, and full of kindly affection towards all, he has left a memory that will be long and lovingly cherished.

NATHANIEL LANGDON FROTHINGHAM was born in Boston, July 23, 1793. He was graduated at Harvard University in 1811. He pursued the study of theology at Cambridge, under the direction of Dr. Ware, Senior, and from 1812 to 1815 inclusive officiated in the College as instructor in Rhetoric and Oratory. In 1815 he was ordained pastor of the First Church in Boston. In 1818 he married Ann Gorham, daughter of Peter C. Brooks. In 1836 he received the degree of S. T. D. from Harvard University. In 1850 he resigned his parochial charge, retaining the undivided respect and affection of his people, and continuing, until disabled by bodily infirmity, to take an active and efficient interest in the prosperity of the parish, and in the labors and services of his successor in its ministry. His life, during his retirement, was devoted mainly to literary pursuits, hardly impeded by the gradual failure of sight, which terminated in total blindness. Other eyes replaced his own for several years, and his mind retained its clearness, vigor, and fruitfulness for many months after his vision was closed upon the outward world. For the last two or three years, however, disease and infirmity have incapacitated him both for labor and for enjoyment, and life was becoming a weariness and a burden, when it was mercifully closed on the 4th of April, 1870.

Dr. Frothingham's distinction lay in the purity, keenness, delicacy, and high culture of the æsthetic nature. In other respects the peer of able and accomplished men, in this he could have had, if here and there an equal, no superior. Taste was in him genius, wisdom, and power. It imparted a new and rare beauty, even to trite thoughts; it crystallized his scholarship in the most graceful forms; it gave law to his most indifferent words and acts.

He was a scholar by inclination and by lifelong habit. He was well versed equally in classical and in modern literature. He became familiar with the German language at a very early period, and was well read in German theology, while intimately conversant with the poetry and imaginative literature to which that language is the key. By no means narrowly utilitarian, he loved all knowledge for its own sake, without reference to its availableness for immediate service; and he thus became possessed of much of that rare and recondite erudition which enriches and fertilizes the mind, though it may contribute but little to one's professional ability or fame.

As a preacher, Dr. Frothingham held a high and somewhat unique position. His sermons were most appreciated by minds of the largest culture, and yet in thought and in diction they were not above the comprehension of any person of moderate intelligence. Here his exquisite taste gave at once law, scope, and limit. Quaint, but never irreverent; elegant in style, yet without lapsing into euphuism; never forgetting the solemnity of time, place, and purpose, yet instinctively shunning the mere commonplaces of devout thought; solicitous always to instruct and impress his hearers, and ready to avail himself, for this end, of as wide a diversity of topics, illustrations, and allusions, as was consistent with the sacredness of the occasion, — he wrote few sermons that were not listened to with vivid interest, and held in enduring remembrance. Yet his sermons by no means indicated his full capacity of grappling with the highest and the greatest subjects. He seemed unwilling to write anything that was not whole and complete in itself; and there are many topics on which it is impossible to write a perfectly rounded and finished treatise that can be read in half an hour. He essayed no subject which could not be thus compressed naturally and gracefully. His range therefore, as a preacher, was broad, rather than high or deep; but within that range few ministers have been so uniformly apt, rich, and edifying. He was peculiarly felicitous, not only in his treatment of special occasions for pulpit utterance, but in creating such occasions; so that whatever had worthily claimed the attention or interest of his hearers during the week was not unlikely on Sunday to be presented in its religious aspects and lessons.

As a poet, Dr. Frothingham won indeed a high reputation, but a fame far below his merit. As he wrote no long poem, and published no collection of his poetry till very late in life, the public, and even his friends, awoke but slowly and tardily to the recognition of his genius in this department. But as from time to time a hymn or a metrical composition, in conception a gem of pure radiance in a setting of wonderful beauty, appeared under his signature, in the programme of a religious or civic festival, or in the pages of a monthly or quarterly, it was felt more and more that he was indeed a poet by divine right and gift; and there are some of his lyrics that can hardly fail to perpetuate his name, when all other memorials of him shall have passed away. Here, too, we mark not only "the vision and the faculty divine," but equally the unerring taste, incapable of an incongruous image, a mixed metaphor, an unapt epithet, a halting rhythm, or a forced rhyme. He professed to translate a great many German poems; but he made them all his own. He is, indeed, in these versions, true to the original; but he transposes rather than translates it, seeking not so much for synonymous words and phrases, as for equivalent force and beauty of expression.

In character Dr. Frothingham was worthy of his sacred profession, of the affection with which he was regarded by all who knew him well, and of the general reverence which followed him to his retirement and to his grave. In manners and conversation his strongly marked individuality was so held in check, alike by good taste and by benevolence, as to be piquant indeed, but never otherwise than genial and attractive. He had many warm friends, perhaps few intimates. Generous, hospitable, kind, tenderly thoughtful for the feelings and the rights of others, he did untold good in those quiet, unostentatious ways in which genuine philanthropy can work without shout or song. He was conservative both from taste and from principle; but his conservatism had in it no bitterness or exclusiveness, — he only preferred doing good in his accustomed ways, while he conceded cordially the freedom of choice he claimed. As a pastor, he was tenderly beloved; and in all professional, social, and domestic relations he has left only the most precious and blessed memories.

Dr. Frothingham's only published volumes were "Sermons in the Order of a Twelvemonth" and two volumes of Poems. Of occasional sermons and other pamphlets he printed many. He contributed largely to our best periodical literature, and to every important publication of that kind issued in Boston, for considerably more than half a century; and his papers thus published, and because of their form forgotten, would fill nearly half as many volumes as they covered years.

Theodore Strong was born at South Hadley, Massachusetts, in July, 1790, and died at New Brunswick, New Jersey, February 1, 1869. His father was a clergyman, and there had been an unbroken line of ministers in the family of his mother for eleven generations. He took his bachelor's degree at Yale in 1812, and was immediately appointed tutor in Mathematics at Hamilton College, Clinton, New York. He was soon after appointed Professor of Mathematics and Natural Philosophy, and held that chair until 1827, when he was called to the similar chair made illustrious by the genius of Dr. Robert Adrain, at Rutgers College, New Brunswick, New Jersey, where he continued in active duty until 1862. He married, in 1819, Lucy Dix, of Boston, who survives him, with three of their seven children; one son of great promise, who was in the army, fell during the late civil war.

As a teacher Dr. Strong was remarkable for his faith in spontaneous effort, and his utter want of faith in any sort of coercion; he would arouse the enthusiasm of his pupils to study subjects, not compel them to study books. With this faith in the value of spontaneous effort, his desire was more earnest to affect the character of the students than merely to give them specific knowledge; and with his firm convictions of the truth of the Christian religion, he sought ever earnestly to awaken religious life in his scholars, as the most effectual means of arousing intellectual life.

All his convictions, whether in religion, philosophy, or politics, were very strong, held with extreme tenacity, and, if attacked, defended with courteous but earnest warmth. It was said that he never failed, in the College Faculties with which he was connected, to bring the majority to his views. His conclusions were never hasty; he was a patient thinker and careful reader, and took especial pleasure in the writings of the deeper English theologians. His firmness of conviction gave pleasure even to those who differed from him; no man could resist the attraction of his frank, honorable self-poise; and it was good also to look upon a man of such robust health, maintained by habits of great activity and cheerful self-control.

His mathematical powers lay rather in the direction of geometry than in analysis, yet his analytical power was also great. He was too far advanced in years, at the time when the modern rapid developments began, to be much affected by them, but has himself taken important steps.

The following is an imperfect list of Dr. Strong's mathematical writings: —

1. Twenty-two communications in Gill's Mathematical Miscellany.
2. Seven communications in the Cambridge Miscellany.
3. Twenty-two papers in the American Journal of Science, viz.: —
    On Trigonometric and Diophantine Problems, Vols. I. and XXXI.

Problems with Geometrical Construction, Vol. II.
On the Binomial Theorem, Vol. XII.
On Central Forces, Vols. XVI., XVII., XIX., XXI., XXII.
Capillary Attraction, Vol. XVIII.
On the Motion of a System of Bodies, Vols. XXIV., XXV., XXVI.
Parallelogram of Forces, Vols. XXVI., XXIX.
Composition and Resolution of Forces, Vol. XXVIII.
Variation of Constants in Elliptic Motion, Vol. XXX.
Virtual Velocities, Vols. XLII., XLIII.
Differential Equations, Vol. XLII.
Differential Calculus, and Taylor's Theorem, Vol. XLV.
Exponential and Logarithmic Theorems, Vol. XLVIII.

4. A Paper in Runkle's Mathematical Monthly for April, 1860, on the Extraction of Roots, and one in June, 1861, on the Equilibrium of the Lever.

5. A Treatise on Elementary and Higher Algebra, New York, 1859.

6. A Treatise (in MSS.) on the Differential and Integral Calculus.

It would be difficult to find in the history of science a character more simple, more noble, or more symmetrical in all its parts than that of THOMAS GRAHAM, and he will always be remembered as one of the most eminent of those great students of nature, who have rendered our Saxon race illustrious. He was born of Scotch parents in Glasgow in the year 1805, and in that city, where he received his education, all his early life was passed. In 1837 he went to London as Professor of Chemistry in the newly established London University now called University College, and he occupied this chair until the year 1855, when he succeeded Sir John Herschel as Master of the Royal Mint, a post which he held to the close of his life. His death, on the 16th of September last, at the age of sixty, was caused by no active disease, but was simply the wearing out of a constitution enfeebled in youth by privations voluntarily and courageously encountered that he might devote his life to scientific study. As with all earnest students, that life was uneventful, if judged by ordinary standards; and the records of his discoveries form the only materials for his biography. Although one of the most successful investigators of Physical Science, the late Master of the Mint had not that felicity of language or that copiousness of illustration, which added so much to the popular reputation of his distinguished contemporary, Faraday; but his influence on the progress of science was not less marked or less important. Both of these eminent men were for a long period of years best known to the English public as teachers of Chemistry, but their investigations were chiefly limited to physical problems; yet, although both cultivated the border ground between Chemistry and Physics, they followed wholly different lines of research. While Faraday was so successfully developing the principles of electrical action, Graham with equal success was investigating the laws of molecular motion. Each followed with wonderful constancy, as well as skill, a single line of study from first to last, and to this concentration of power their great discoveries are largely due.

One of the earliest and most important of Graham's investigations, and the one which gave the direction to his subsequent course of study, was that on the diffusion of gases. It had already been recognized that impenetrability in its ordinary sense is not, as was formerly supposed, a universal quality of matter. Dalton had not only recognized that aëriform bodies exhibit a positive tendency to mix, or to penetrate through each other, even in opposition to the force of gravity, but had made this quality of gases the subject of experimental investigation. He inferred, as the result of his inquiry, "that different gases afford no resistance to each other; but that one gas spreads or expands into the space occupied by another gas, as it would rush into a vacuum; at least, that the resistance which the particles of one gas offer to those of another is of a very imperfect kind, to be compared to the resistance which stones in the channel of a stream oppose to the flow of running water." But although this theory of Dalton was essentially correct and involved the whole truth, yet it was supported by no sufficient evidence, and he failed to perceive the simple law which underlies this whole class of phenomena.

Graham, "on entering on this inquiry, found that gases diffuse into the atmosphere with different degrees of ease and rapidity." This was first observed by allowing each gas to diffuse from a bottle into the air through a narrow tube in opposition to the solicitation of gravity. Afterwards an observation of Doebereiner on the escape of hydrogen gas by a fissure or crack in a glass receiver caused him to vary the conditions of his experiments, and led to the invention of the well-known "Diffusion Tube." In this simple apparatus a thin septum of plaster of Paris is used to separate the diffusing gases, which, while it arrests in a great measure all direct currents between the two media, does not interfere with the molecular motion. Much later, Graham found in prepared graphite a material far better adapted to this purpose than the plaster, and he used septa of this mineral to confirm his early results, in answer to certain ill-considered criticisms in Bunsen's work on Gasometry. These septa he was in the habit of calling his "atomic filters." By means of the diffusion tube Graham was able to measure accurately the relative times of diffusion of different gases, and he found that *equal volumes of any two gases interpenetrate each other in times which are inversely proportional to the square roots of their respective densities*, and this fundamental law was the greatest discovery of our late Foreign Associate. It is now universally recognized as one of the few great cardinal principles which form the basis of Physical Science.

It can be shown, on the principles of pneumatics, that gases should rush into a vacuum with velocities corresponding to the numbers which have been found to express their diffusion times; and, in a series of experiments on what he calls the "*Effusion*" of gases, Graham confirmed by trial this deduction of theory. In these experiments a measured volume of the gas was allowed to find its way into the vacuous jar through a minute aperture in a thin metallic plate, and he carefully distinguished between this class of phenomena and the flowing of gases through capillary tubes into a vacuum, in which case, however short the tube, the effects of friction materially modify the result. This last class of phenomena Graham likewise investigated, and designated by the term "Transpiration."

While, however, it thus appears that the results of Graham's investigation were in strict accordance with Dalton's theory, it must also be evident that Graham was the first to observe the exact numerical relation which obtains in this class of phenomena, and that all-important circumstance entitles him to be regarded as the discoverer of the law of Diffusion. The law, however, as first enunciated, was purely empirical, and Graham himself says that something more must be assumed than that gases are vacua to each other, in order to explain all the phenomena observed; and according to his original view this representation of the process was only a convenient mode of expressing the final result. Such has proved to be the case.

Like other great men, Graham built better than he knew. In the progress of Physical Science during the last twenty-five years, two principles have become more and more conspicuous, until at last they have completely revolutionized the philosophy of Chemistry. In the first place it has appeared that a host of chemical as well as of physical facts are co-ordinated by the assumption that all substances in the state of gas have the same molecular volume, or, in other words, contain the same number of molecules in a given space; and in the second place, it has become evident that the phenomena of heat are simply the manifestations of molecular motion. According to this view, the temperature of a body is the *vis viva* of its molecules; and since all molecules at a given temperature have the same *vis viva*, it follows that the molecules must move with velocities which are inversely proportional to the square roots of the molecular weights. Moreover, since the molecular volumes are equal, and the molecular weights therefore proportional to the densities of the aëriform bodies in which the molecules are the active units, it also follows that the velocities of the molecules in any two gases are inversely proportional to the square roots of their respective densities. Thus the simple numerical relations first observed in the phenomena of diffusion are the direct result of molecular motion, and it is now seen that Graham's empirical law is included under the fundamental laws of motion. Thus Graham's investigation has become the basis of the new science of molecular mechanics, and his measurements of the rates of diffusion prove to be the measures of molecular velocities.

From the study of diffusion Graham passed by a natural transition to the investigation of a class of phenomena which, although closely allied to the first, as to the effects produced, differ wholly in their essential nature. Here also he followed in the footsteps of Dalton. This distinguished chemist had noticed that a bubble of air separated by a film of water from an atmosphere of carbonic anhydride gradually expanded until it burst. In like manner a moist bladder, half filled with air and tied, if suspended in an atmosphere of the same material, becomes in time greatly distended by the insinuation of this gas through its substance. This effect cannot be the result of simple diffusion, for it is to be remembered that the thinnest film of water, or of any liquid, is absolutely impermeable to a gas as such, and, moreover, only the carbonic anhydride passes through the film, very little or none of the air escaping outward. The result depends, first, upon the solution of the carbonic anhydride by the water on one surface of the film; secondly, on the evaporation into the air, from the other surface, of the gas thus absorbed. Similar experiments were made by Drs. Mitchell and Faust, and others, in which gases passed through a film of india-rubber, entering into a partial combination with the material on one surface, and escaping from it on the other.

Graham not only considerably extended our knowledge of this class of phenomena, but also gave us a satisfactory explanation of the mode in which these remarkable results are produced. He recognized in these cases the action of a feeble chemical force, insufficient to produce a definite compound, but still capable of determining a more or less perfect union, as in the case of simple solution. He also distinguished the influence of mass in causing the formation or decomposition of such weak chemical compounds. The conditions of the phenomena under consideration are simply these: —

First. A material for the septum capable of forming a feeble chemical union with the gas to be transferred.

Secondly. An excess of the gas on one side of the film and a deficiency on the other.

Thirdly. Such a temperature that the unstable compound may orm at the surface, where the aëriform constituent is present in large mass, while it decomposes at the opposite surface, where the quantity is less abundant.

One of the most remarkable results of Graham's study of this peculiar mode of transfer of aëriform matter through the very substance of solid bodies was an ingenious method of separating the oxygen from the atmosphere. The apparatus consisted simply of a bag of india-rubber kept distended by an interior framework, while it was exhausted by a Sprengel pump. Under these circumstances the selective affinity of the caoutchouc determines such a difference in the rate of transfer of the two constituents of the atmosphere that the amount of oxygen in the transpired air rises to forty per cent, and by repeating the process nearly pure oxygen may be obtained. It was at first hoped that this method might find a valuable application in the arts, but in this Graham was disappointed; for the same result has since been effected by purely chemical methods, which are both cheaper and more rapid.

These experiments on india-rubber naturally led to the study of similar effects produced with metallic septa, which, although to some extent previously observed in passing gases through heated metallic tubes, had been only imperfectly understood. Thus, when a stream of hydrogen or carbonic oxide is passed through a red-hot iron tube, a no inconsiderable portion of the gas escapes through the walls. The same is true to a still greater degree when hydrogen is passed through a red-hot tube of platinum, and Graham showed that through the walls of a tube of palladium hydrogen gas passes, under the same conditions, almost as rapidly as water through a sieve. Moreover, our distinguished Associate proved that this rapid transfer of gas through these dense metallic septa was due, as in the case of the india-rubber, to an actual chemical combination of its material with the metal, formed at the surface, where the gas is in excess, and as rapidly decomposed on the opposite face of the septum. He not only recognized as belonging to this class of phenomena the very great absorption of hydrogen by platinum plate and sponge in the familiar experiment of the Doebereiner lamp, but also showed that this gas is a definite constituent of meteoric iron, — a fact of great interest from its bearing on the meteoric theory.

We are thus led to Graham's last important discovery, which was the justification of the theory we have been considering, and the crowning of this long line of investigation. As may be anticipated from what has been said, the most marked example of that order of chemical compounds, to which the metallic transpiration of aëriform matter we have been considering is due, is the compound of palladium with hydrogen. Graham showed that when a plate of this metal is made the negative pole in the electrolysis of water, it absorbs nearly one thousand times its volume of hydrogen gas, — a quantity approximatively equivalent to one atom of hydrogen to each atom of palladium. He further showed that the metal thus becomes so profoundly altered as to indicate that the product of this union is a definite compound. Not only is the volume of the metal increased, but its tenacity and conducting power for electricity are diminished, and it acquires a slight susceptibility to magnetism, which the pure metal does not possess. The chemical qualities of this product are also remarkable. It precipitates mercury from a solution of its chloride, and in general acts as a strong reducing agent. Exposed to the action of chlorine, bromine, or iodine, the hydrogen leaves the palladium and enters into direct union with these elements. Moreover, although the compound is readily decomposed by heat, the gas cannot be expelled from the metal by simple mechanical means.

These facts recall the similar relations frequently observed between the qualities of an alloy and those of the constituent metals, and suggest the inference made by Graham, that palladium charged with hydrogen is a compound of the same class, — a conclusion which harmonizes with the theory long held by many chemists, that hydrogen gas is the vapor of a very volatile metal. This element, however, when combined with palladium, is in a peculiarly active state, which sustains somewhat the same relation to the familiar gas that ozone bears to ordinary oxygen. Hence Graham distinguished this condition of hydrogen by the term "Hydrogenium." Shortly before his death a medal was struck at the Royal Mint from the hydrogen palladium alloy in honor of its discovery; but although this discovery attracted public attention chiefly on account of the singular chemical relations of hydrogen, which it brought so prominently to notice, it will be remembered in the history of science rather as the beautiful termination of a life-long investigation, of which the medal was the appropriate seal.

Simultaneously with the experiments on *gases*, whose results we have endeavored to present in the preceding pages, Graham carried forward a parallel line of investigation of an allied class of phenomena, which may be regarded as the manifestations of molecular motion in *liquid* bodies. The phenomena of diffusion reappear in liquids, and Graham carefully observed the times in which equal weights of various salts dissolved in water diffused from an open-mouth bottle into a large volume of pure water, in which the bottle was immersed. He was not, however, able to correlate the results of these experiments by such a simple law as that which obtains with gases. It appeared, nevertheless, that the rate of diffusion differs very greatly for the different soluble salts, having some relation to the chemical composition of the salt which he was unable to discover. But he found it possible to divide the salts into groups of equi-diffusive substances, and he showed that the rates of diffusion of the several groups bear to one another simple numerical ratios.

More important results were obtained from the study of a class of phenomena corresponding to the transpiration of gases through india-rubber or metallic septa. These phenomena, as manifested in the transfer of liquids and of salts in solution through bladder, or a similar membrane, had previously been frequently studied under the names of exosmose and endosmose, but to Graham we owe the first satisfactory explanation. As in the case of gases, he referred these effects to the influence of chemical force, combination taking place on one surface of the membrane, and the compound breaking up on the other, the difference depending, as in the previous instance, on the influence of mass.

He also swept away the arbitrary distinctions made by previous experimenters, showed that this whole class of phenomena are essentially similar, and called this manifestation of power simply "osmose."

While studying osmotic action, Graham was led to one of his most important generalizations, — the recognition of the crystalline and amorphous states as fundamental distinctions in chemistry. Bodies in the first state he called crystalloids; those in the last state, colloids (resembling glue). That there is a difference in structure between crystalloids, like sugar or felspar, and colloids, like barley candy or glass, has of course always been evident to the most superficial observer; but Graham was the first to recognize in these external differences two fundamentally distinct conditions of matter not peculiar to certain substances, but underlying all chemical differences, and appearing to a greater or less degree in every substance. He showed that the power of diffusion through liquids depends very much on these fundamental differences of condition, — sugar, one of the least diffusible of the crystalloids, diffusing fourteen times more rapidly than caromel, the corresponding colloid. He also showed that, in accordance with the general chemical rule, while colloids readily combine with crystalloids, bodies in the same condition manifest little or no tendency to chemical union. Hence in osmose, where the membranes employed are invariably colloidal, the osmotic action is confined almost entirely to crystalloids, since they alone are capable of entering into that combination with the material of the septum on which the whole action depends.

On the above principles Graham based a simple method of separating crystalloids from colloids, which he calls "dialysis," and which was a most valuable addition to the means of chemical analysis. A shallow tray, prepared by stretching parchment paper (an insoluble colloid) over a gutta-percha hoop, is the only apparatus required. The solution to be "dialyzed" is poured into this tray, which is then floated on pure water, whose volume should be eight or ten times greater than that of the solution. Under these conditions the crystalloids will diffuse through the porous septum into the water, leaving the colloids on the tray, and in the course of a few days a more or less complete separation of the two classes of bodies will have taken place. In this way arsenious acid and similar crystalloids may be separated from the colloidal materials with which, in the case of poisoning, they are usually found mixed in the animal juices or tissues.

But besides having these practical applications, the method of dialysis in the hands of Graham yielded the most startling results, developing an almost entirely new class of bodies as the colloidal forms of our most familiar substances, and justifying the conclusion that the colloidal as well as the crystalline condition is an almost universal attribute of matter. Thus, he was able to obtain solutions in water of the colloidal states of aluminic, feoric, chromic, stannic, metastannic, titanic, molybdic, tungstic, and silicic hydrates, all of which gelatinize under definite conditions like a solution of glue. The wonderful nature of these facts can be thoroughly appreciated only by those familiar with the subject, but all may understand the surprise with which the chemist saw such hard, insoluble bodies as flint dissolved abundantly in water and converted into soft jellies. These facts are, without doubt, the most important contributions of Dr. Graham to pure chemistry.

In this sketch of the scientific career of our late Associate, we have followed the logical, rather than the chronological, order of events, hoping thus to render the relations of the different parts of his work more intelligible. It must be remembered, however, that the two lines of investigation we have distinguished were in fact interwoven, and that the beautiful harmony which his completed life presents was the result, not of a preconceived plan, but of a constant devotion to truth, and a childlike faith, which unhesitatingly pressed forward whenever nature pointed out the way.

Although the investigations of the phenomena connected with the molecular motion in gases and liquids were by far the most important of Dr. Graham's labors, he also contributed to chemistry many researches which cannot be included under this head. Of these, which we may regard as his detached efforts, the most important was his investigation of the hydrates and other salts of phosphorus. It is true that the interpretation he gave of the results has been materially modified by the modern chemical philosophy, yet the facts which he established form an important part of the basis on which that philosophy rests. Indeed, it seems as if he almost anticipated the later doctrines of types and polybasic acids, and in none of his work did he show more discriminating observation or acute reasoning. A subsequent investigation on the condition of water in several crystalline salts and in the hydrates of sulphuric acid is equally remarkable. Lastly, Graham also made interesting observations on the combination of alcohol with salts, on the process of etherification, on the slow oxidation of phosphorus, and on the spontaneous inflammability of phosphuretted hydrogen. It would not, however, be appropriate in this place to do more than enumerate the subjects of these less important studies; and we have therefore only aimed in this sketch to give a general view of the character of the field which this eminent student of nature chiefly cultivated, and to show how abundant was the harvest of truth which we owe to his faithful toil.

Graham was not a voluminous writer. His scientific papers were all very brief, but comprehensive, and his "Elements of Chemistry" was his only large work. This was an admirable exposition of chemical physics, as well as of pure chemistry, and gave a more philosophical account of the theory of the galvanic battery than had previously appeared. Our late Associate was fortunate in receiving during life a generous recognition of the value of his labors. His membership was sought by almost all the chief scientific societies of the world, and he enjoyed to a high degree the confidence and esteem of his associates. Indeed, he was singularly elevated above the petty jealousies and belittling quarrels, which so often mar the beauty of a student's life, while the great loveliness and kindliness of his nature closely endeared him to his friends. He was never married, keeping house with a sister at No. 4 Gordon Square, where he dispensed a liberal hospitality, which has been enjoyed by many of our scientific countrymen who have visited London during the last twenty years.

In concluding, we must not forget to mention that most genial trait of Graham's character, his sympathy with young men, which gave him great influence as a teacher in the College with which he was long associated. There are many now prominent in the scientific world who have found in his encouragement the strongest incentive to perseverance, and in his approval and friendship the best reward of success.

FREDERIC OVERBECK was born at Lubeck on the 2d of July, 1789, and commenced his studies in art at a very early age. In 1806 he entered the Academy of Fine Arts at Vienna. His natural tendencies, fostered by the counsels of Eberhard Wachter, soon led him to the exclusive study of the Pre-Raphaelite painters. This brought him into such open opposition to the professors, whose principles were those of the classical school of Mengs and David, that he was dismissed from the Academy, and in the year 1810 went to Rome, where he found himself in a thoroughly congenial atmosphere. Six years later, when Niebuhr arrived there as Prussian ambassador, he found Overbeck and other young artists, who were then laying the foundations of the new school of painting in Germany, divided into two parties, professing utterly opposed principles. These were the Nazarenes, so called from their mode of life and their austerity of demeanor, whose leaders, Overbeck, Wilhelm, Schadow, and Veit, late converts to Romanism, looked upon art as the servant of religion, and lived like monks in the old convent of San Isidoro, preparing their simple meals in the kitchen of the convent; and the Pagans, as they might have been denominated, who were devout adorers of the antique. This latter party numbered Thorwaldsen, Koch, and Schlick in its ranks. Cornelius stood midway between the two parties, but his dislike of the proselytism which was practised by the Nazarenes rather impelled him in the opposite direction; and, although a Catholic, he openly said that when they made their first convert he would become a Protestant.

Niebuhr tells us that the Catholicism of Cornelius was at bottom nothing more than the creed of the old Protestants, "thanks to the training which he had received from a pious, though by no means bigoted mother"; but Overbeck, he adds, "is, on the contrary, an enthusiast, and quite illiberal; he is a very amiable man and endowed with a magnificent imagination, but incapable by nature of standing alone, and by no means so clear-headed as he is practical."

In the society of such men as Niebuhr, Bunsen, and Brandis these artists met on the most friendly terms, though certain topics (*teste* Niebuhr) were necessarily excluded from conversation on account of the Catholicism of Overbeck and Schadow.

A few years after Overbeck had settled at Rome, the Prussian Consul-General, Salomm Bartholdy (Mendelssohn's uncle), proposed to him, together with Veit, Schadow, and Cornelius, to decorate with frescos a room in the Palazzo Zuccheri, where he resided, offering himself to meet all material expenses. Thus these young and ardent spirits were enabled to carry out their long-cherished project of reviving an almost forgotten art in the very city where its greatest masterpieces had been executed, nearly three centuries before, by the hands of Raphael and Michael Angelo.

The history of Joseph was selected for treatment, and Overbeck painted the episode of Joseph sold by his brethren to the Ishmaelites. In this, his first important work, the young artist displayed his lifelong merits and defects. We need go no farther to understand him; for, unlike men of original genius, Overbeck had but one style, or, to speak more correctly, but one manner, which too often degenerated into mannerism. He was in no sense progressive; his art wanted individual life; it was a plant carefully trained after the outward pattern of a phase of art which still keeps its high place because it was the spontaneous growth and vital expression of the age which produced it, — a ghost clad in Pre-Raphaelite garments, cold, correct, full of evidences of careful study, but never inspired, never living. Now and then, as in this very fresco, or in his great picture of The Influence of Religion upon the Arts in the Staedel Institute at Frankfort, we are charmed by a naive grace and simplicity; but this is because we are thinking of Perugino, rather than of Overbeck.

After completing their work at the Palazzo Zuccheri, Overbeck, Schadow, and Cornelius painted frescos, representing scenes selected from the poems of the four great Italian poets, in the casino of the villa of Prince Massimo, near St. John Lateran. Overbeck took his subject from Tasso; but he was not the man required for such a work, and could not rise to the same level as when his pencil was employed upon Biblical scenes. In dealing with these he was in his element, and the long series of charcoal drawings which he commenced, while living at the Palazzo Cenci, for an illustrated German Bible, are, as it seems to us, by far his best works. For color he had no feeling. His oil pictures are positively disagreeable from their leaden tones, false scale of crude tints, and inharmonious juxtaposition of colors; but his simple outline drawings, only slightly shaded, are masterly. His most important paintings, besides those already mentioned, are the Miracle of St. Francis and the Roses, in the Church of Sta. Maria degli Angeli at Assisi; Christ in the Garden, at Hamburg; and the Entrance of Christ into Jerusalem, in the Church of the Virgin at Lubeck. After residing fifty-nine years at Rome, Overbeck died there of rapid consumption on the 12th of November, 1869.

No one who has ever seen him can forget his striking appearance. Like his art, he was an anachronism. Clad in a long purple robe bordered with gray fur, and wearing a cap of the same material and trimmings upon his head, grave and sober in his walk and conversation, he looked as if he had stepped out of one of Holbein's pictures. Could he have been set down in the Rotterdam of the sixteenth century, he might have met Erasmus without startling him as he startled the stranger of our day who saw him for the first time in the streets of Rome or in his studio on the Esquiline.

He was so gentle and kindly that all felt drawn towards him, while at the same time his reverend aspect inspired those who approached him with veneration. The purity of his life was reflected in his person, as in his art, and the atmosphere which surrounded him was so far removed from the tumultuous rush of modern existence, that when you left him, and plunged again into the world as it is, you carried away a thousand longings for that world of which he seemed a part. Overbeck was a priest of Art, to whom it was a holy thing, and never a means of gaining money or men's applause.

The thanks of the Academy were voted to the retiring Secretary, Mr. Wright, for his long and faithful service.

Six hundred and twenty second Meeting.

June 14, 1870. — ADJOURNED ANNUAL MEETING.

The PRESIDENT in the chair.

Letters in acknowledgment of their election as Fellows were received from C. C. Perkins, Esq., Professor N. Holmes, and Dr. George Derby.

Dr. J. B. S. Jackson was appointed to the Auditing Committee in place of Dr. Ware, absent in Europe.

Professor Lovering proposed that Chapter I., Section II., of the Statutes of the Academy, be amended by the substitution of the word " five" for " three," and also for the word " two," so that the article shall read " and an annual assessment of five dollars, with such additional sum, not exceeding five dollars, as the Academy shall, by a standing vote, from time to time determine." Referred to a committee consisting of Messrs. Lovering, Clark, and Quincy.

The President called attention to the fact, that, in the new Dictionary of Latin and Byzantine Greek by Professor Sophocles, no mention is made of the " Glossary," published by the Academy as the seventh volume of its Memoirs, of which